

Qualification of a 12-Fiber Ribbon Cable for Space Flight

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Our website: misspiggy.gsfc.nasa.gov/photronics

Outline

- **Qualification Testing Methodology**
- **Optical Fiber Construction**
- **Previous Qualification (over past 10 years)**
- **Current Qualification Activities**
- **Explanation of Results**
- **Conclusions**

Qualification Testing

- Optical component qualification
 - Vibration testing
 - Thermal testing
 - Operating Range
 - Survival Range
 - Radiation testing
 - Transmission loss and annealing

Test levels are determined based on system application.

Qualification testing should include margin as a risk reduction to requirement changes late in the program.

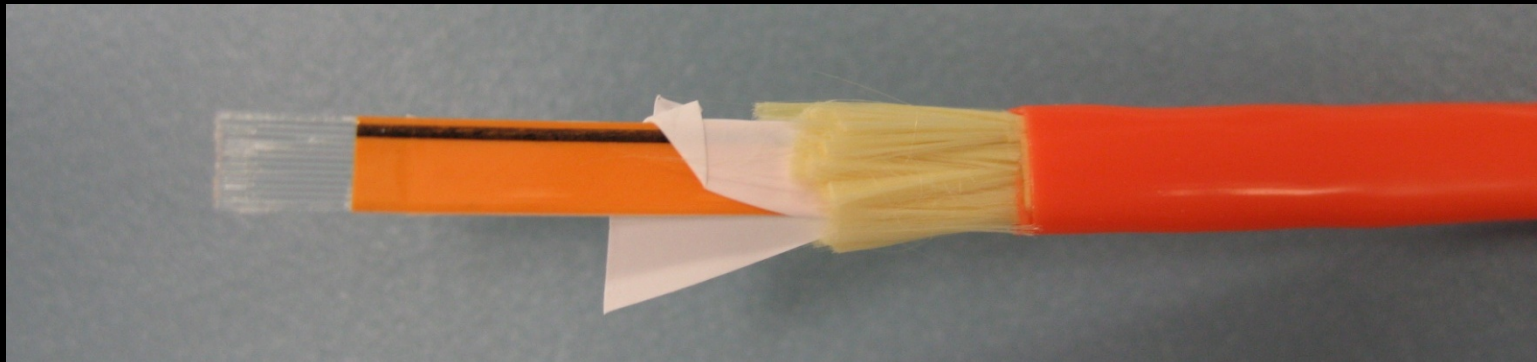
Qualification

- Desirable to use commercial-off-the-shelf (COTS) components when possible
 - Alleviate tight budget and schedule
 - Often requires custom packaging

Just because it worked 10 years ago, does not mean that it will perform exactly the same today.

Requalification must be performed to verify current product meets requirements.

12-Fiber Optical Ribbon Cable



- Cable construction
 - Fibers laminated in Mylar with Teflon wrap
 - Kevlar strength member
 - Outer polymer jacket
- Kevlar strength member crimped to back of connector and isolated from outer polymer jacket on one end of cable
 - Allow jacket to pull back if additional shrinkage
- Outer polymer jacket crimped to connector on other end of cable

Cable Configurations

Straight 6 meter



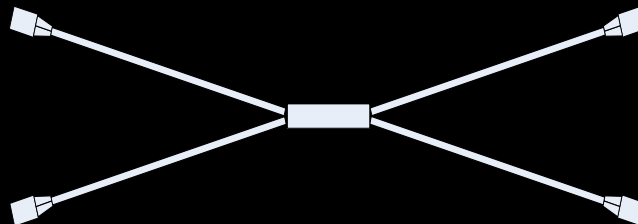
MTP connectors on both ends

In-cable Terminations



MTP connectors on ends with
MT connectors in cable

Cross-over Cable



MTP connectors
on all ends



Previous Qualification

- Vibration Test
 - 3 axis test, 3 minutes per axis, 12.78 Grms total
 - 2 channels monitored on each cable, total 48 tests conducted
 - Max. change during testing of around 0.5 dB
 - One MT mating exhibited sign of “pits”
- Thermal Vacuum Test
 - -25°C to +80 °C, 60 thermal cycles total, vacuum 10^{-6} to 10^{-8} Torr
 - 6 cables and total 12 channels monitored actively
 - Max. change of 1.9 dB with max change within cycle of 1.5 dB
- Radiation Test
 - Two dose rates used to provide a model for extrapolation to lower dose rates
 - High dose rate resulted in 2.1dB/m, and low dose rate 2.4 dB/m
 - Extrapolated to 1 rad/min, ~ 1.6 dB/m for 12 Mrads at room temperature

Melanie N. Ott, Joy W. Bretthauer, Photonics For Space Environments VI, Proceedings of SPIE Vol. 3440, 1998.

Melanie N. Ott, Shawn Macmurphy, and Pat Friedberg, SPIE Aerosense Conference Proceedings, Vol. 4732, April 2002

Xiaodan Jin, Melanie N. Ott, Frank V. LaRocca, Ronald M. Baker, et. al., SPIE Optics and Photonics Conference , Vol 6308, Aug 2006.

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Current Qualification Activities

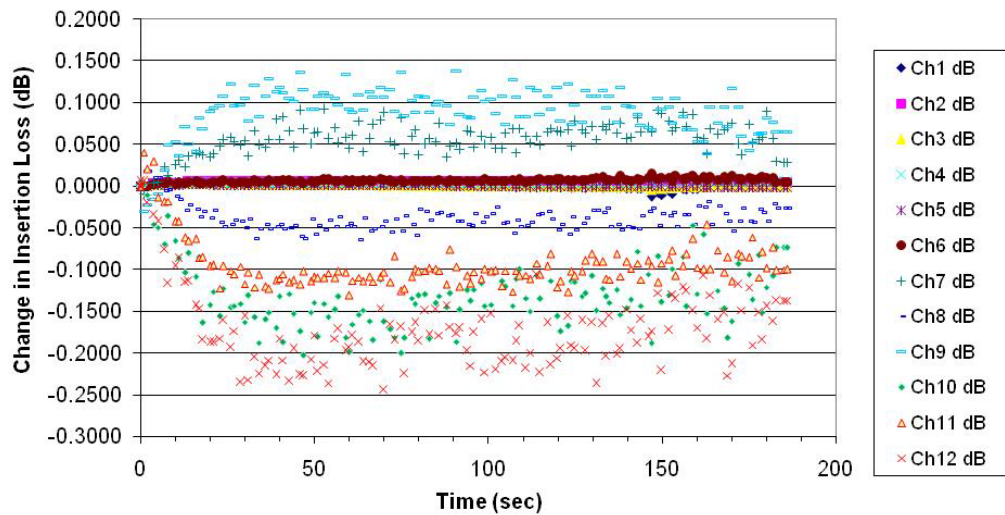
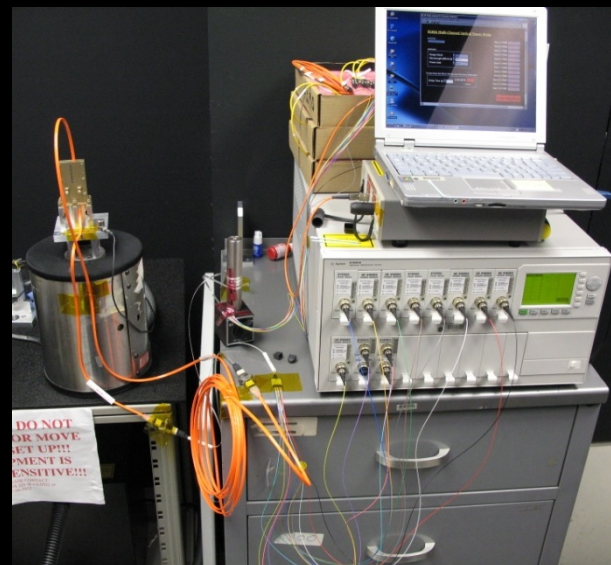
- Cables preconditioned and manufactured by outside vendor
- GSFC received finished cables for qualification testing
 - Random vibration = 12.78 Grms
 - Thermal Operational = -20°C to 90°C, 60 cycles
 - Thermal Survival = -50°C to 100°C, 20 cycles
 - Radiation Testing

Vibration Testing

12.78 Grms
 3 min per axis

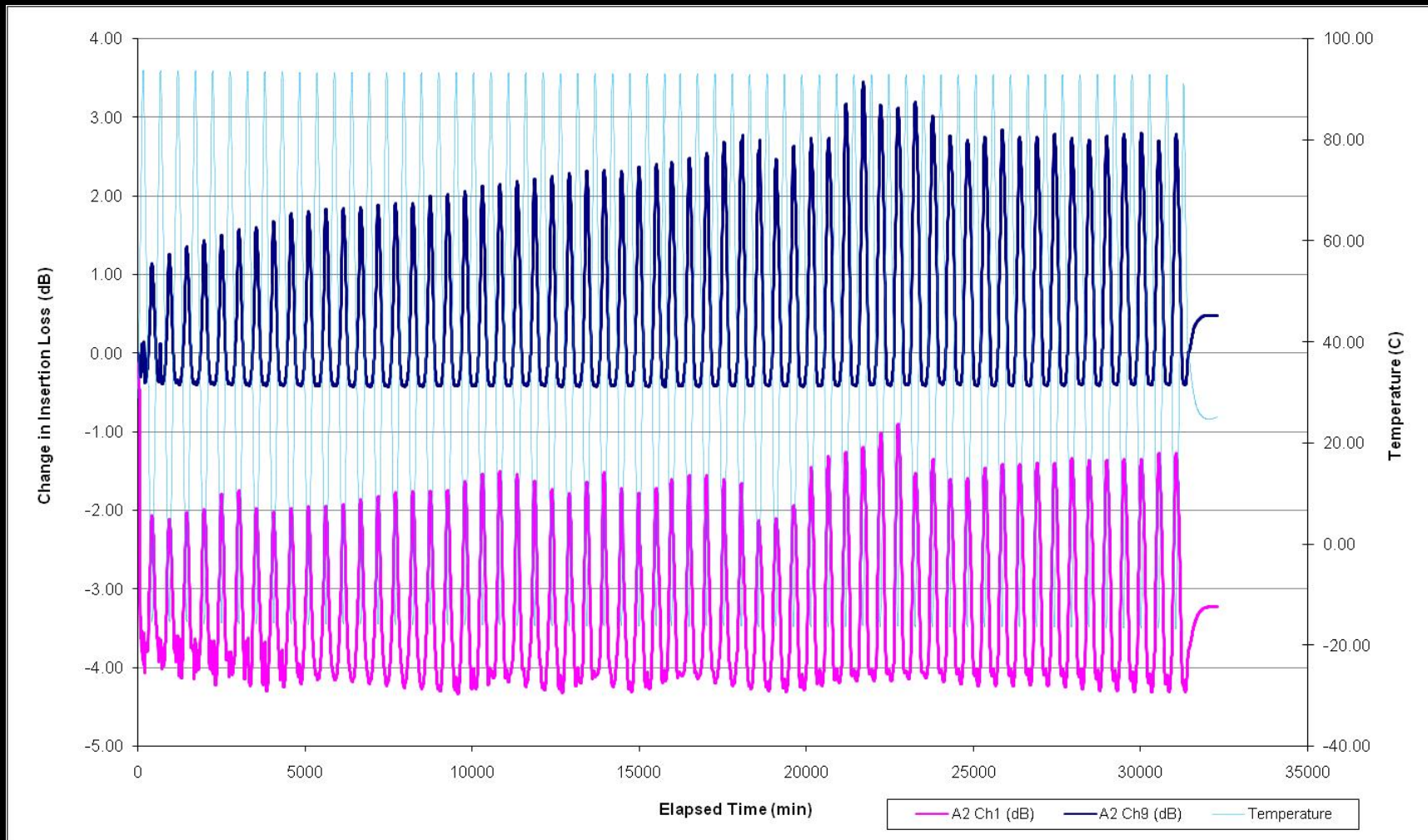
Specification of 0.5 dB maximum change

All cables within specification



Thermal Testing

Operational Range



-20°C to 90°C
 60 Cycles

6 m cable with MTP connectors

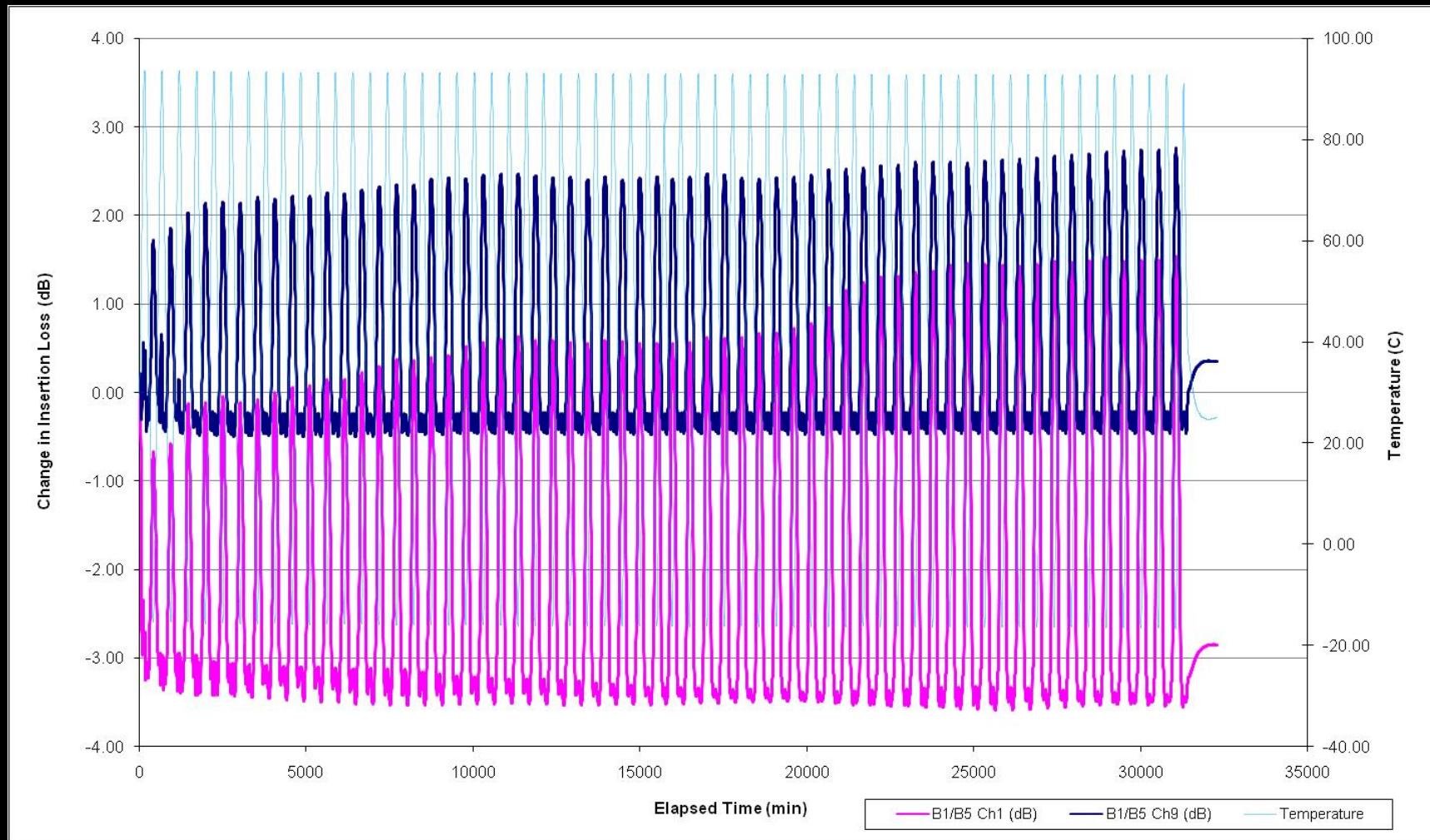
Specification of
 1.9 dB maximum change

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Thermal Testing

Operational Range



-20°C to 90°C
 60 Cycles

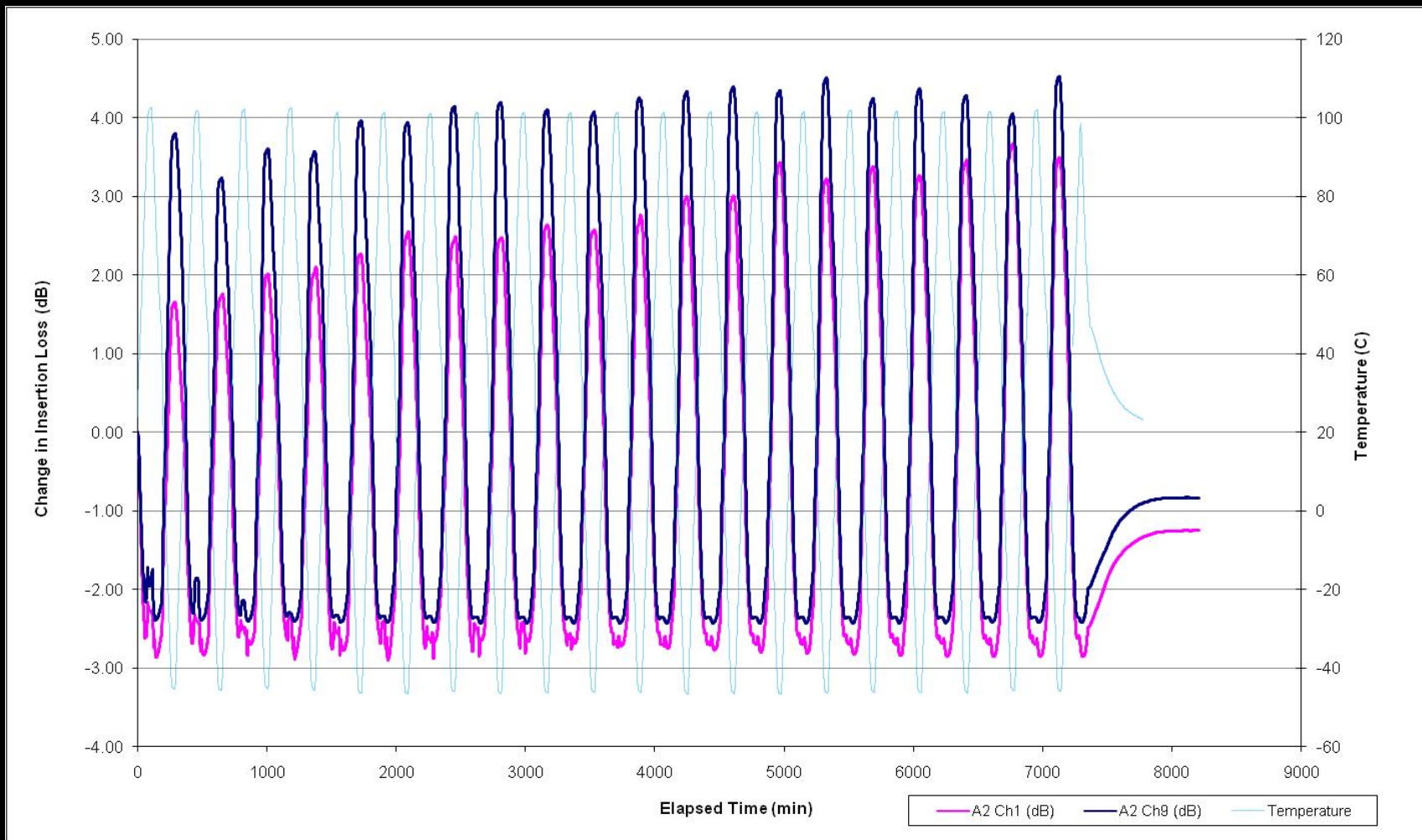
6 m cable with MT connectors in cable

Specification of
 1.9 dB maximum change

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Thermal Testing *Survival Range*



-50°C to 100°C
20 Cycles

6 m cable with MTP connectors

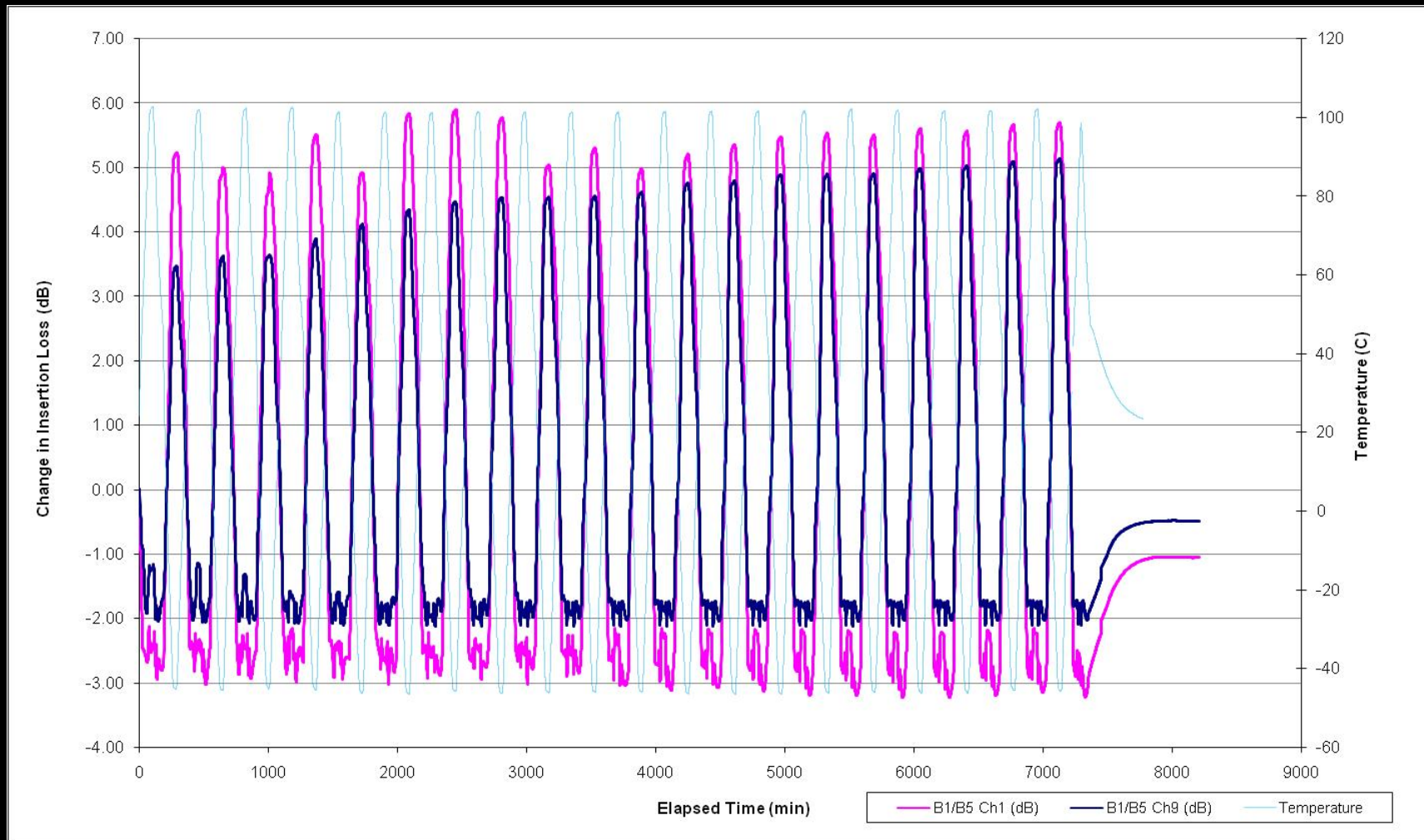
Specification of
1.9 dB maximum change

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Thermal Testing

Survival Range



-50°C to 100°C
 20 Cycles

6 m cable with MT connectors in cable

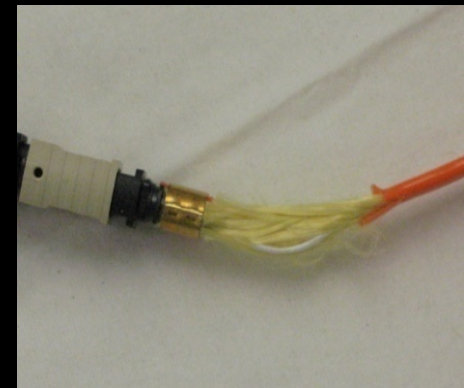
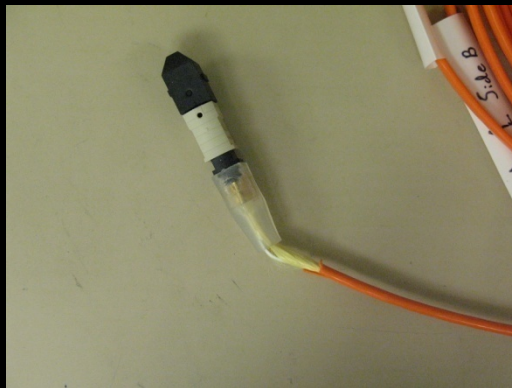
Specification of
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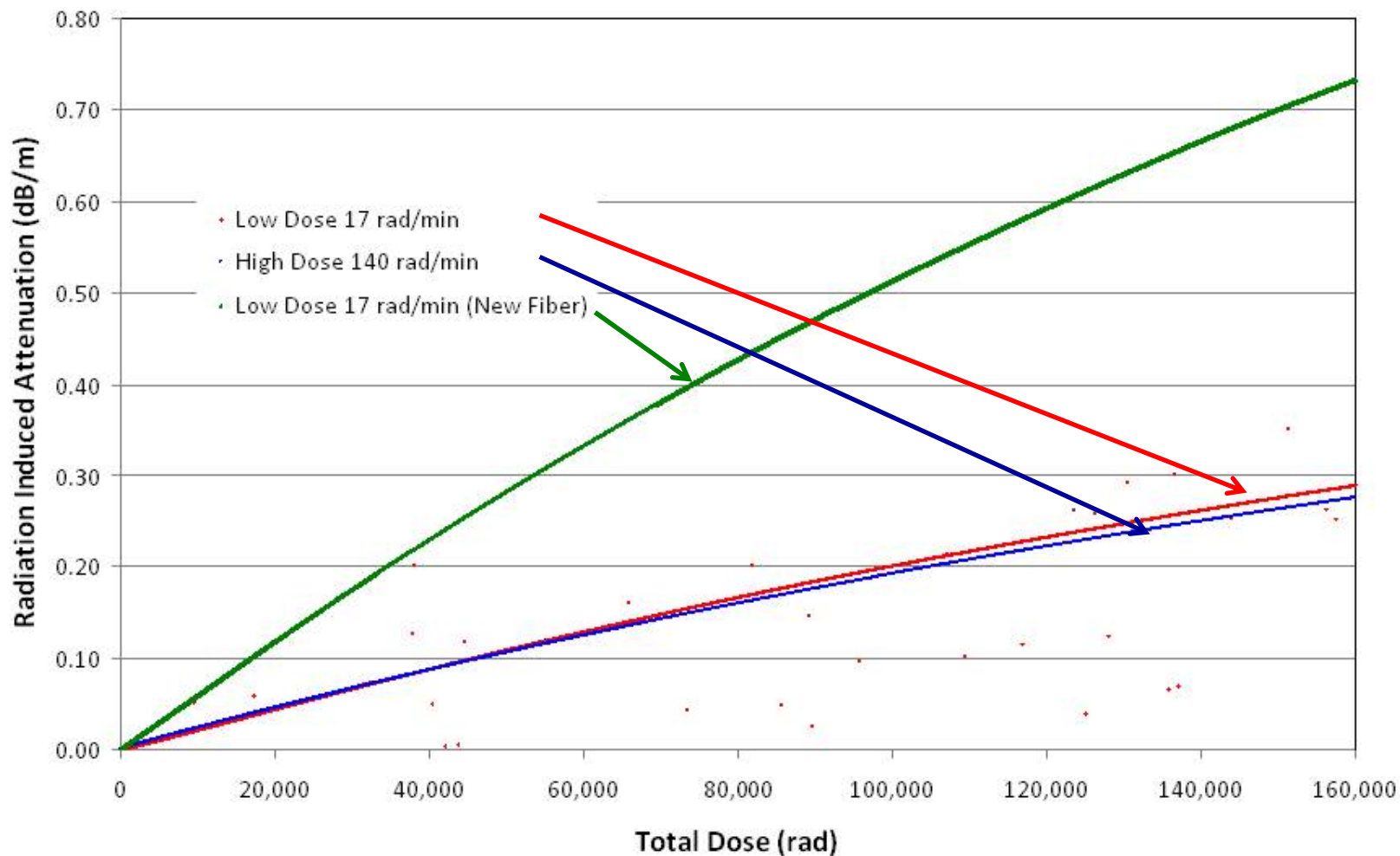
<http://misspiggy.gsfc.nasa.gov/photronics>

Explanation of Thermal Results

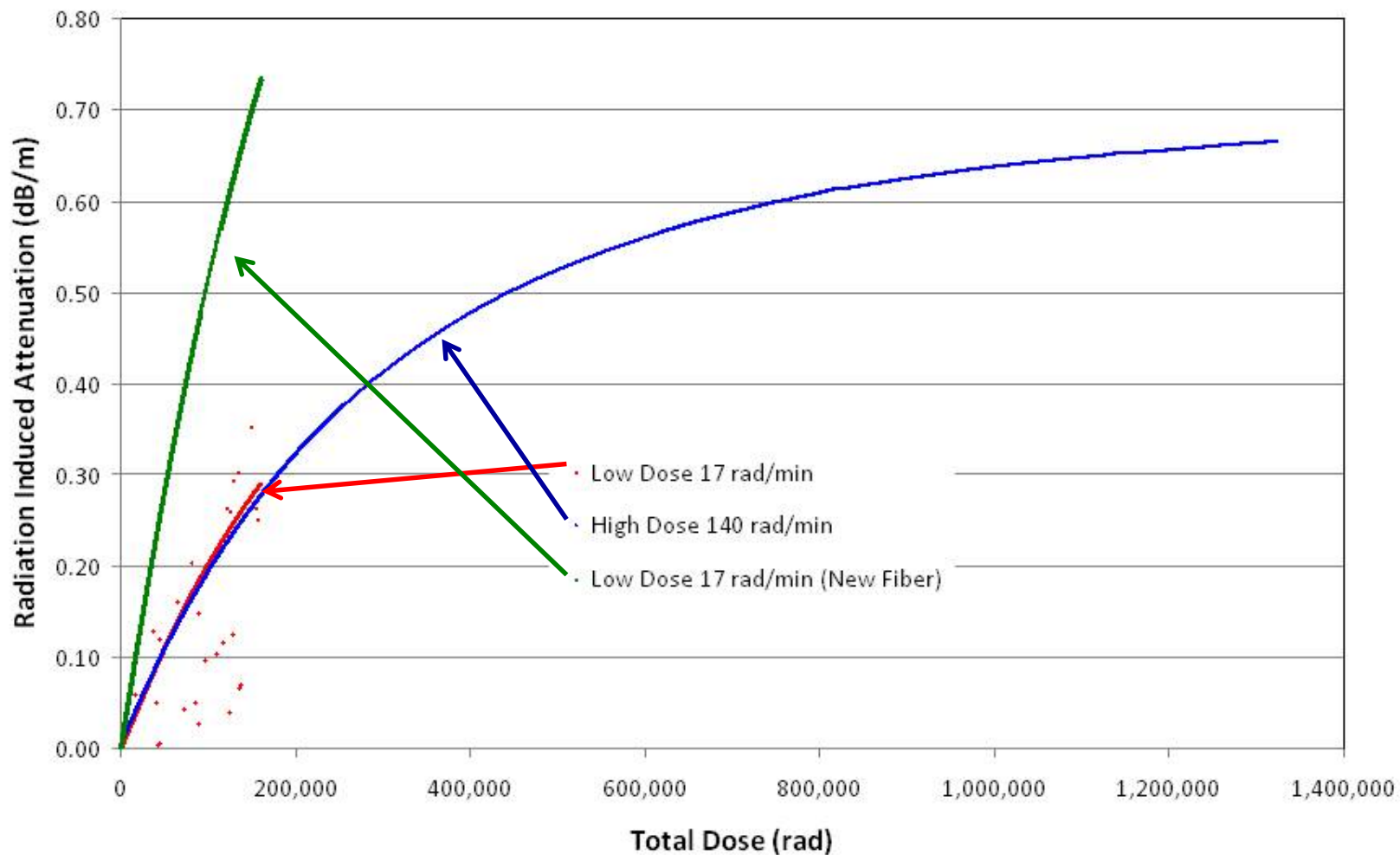
- Increasing insertion loss in cables with thermal cycling suggests cables are shrinking
- Cables were improperly preconditioned by customer before terminations were added
- Stress in cable behind connector was causing large loss in optical transmission



Radiation Testing



Radiation Testing



Conclusions

- Improper preconditioning of fiber optic cables by customer resulted in unacceptable performance during qualification testing
- Radiation testing revealed differences in fiber optic cable manufacturing

Conclusions

- Just because it worked many years ago does not mean that it will work the same today
 - Qualification testing to make sure it will meet requirements
- COTS parts often require custom packaging, conditioning, or modification for space flight
- Need to work people that have a history and know how the parts have change over time
 - We establish long term relationships with vendors and remain current on process changes to product offerings